SOUTH AUSTRALIA.

DEPARTMENT OF MINES.

Geological Survey of South Australia.

REPORT No. 1.

THE YELTA AND PARAMATTA MINES.

BY

L. KEITH WARD, B.A., B.E., Government Geologist,

AND

R. LOCKHART JACK, B.E., F.G.S., Assistant Government Geologist.

Issued under the authority of

The Honorable RICHARD BUTLER, M.P., Minister of Mines.

ADELAIDE:

R. E. E. ROGERS, GOVERNMENT PRINTER, NORTH TERRACE.

1912.

SOUTH AUSTRALIA.

DEPARTMENT OF MINES.

Geological Survey of South Australia.

REPORT No. 1.

THE YELTA AND PARAMATTA MINES.

BY

L. KEITH WARD, B.A., B.E., Government Geologist,

AND

R. LOCKHART JACK, B.E., F.G.S., Assistant Government Geologist.

Issued under the authority of

The Honorable RICHARD BUTLER, M.P., Minister of Mines.

ADELAIDE:

R. E. E. ROGERS, GOVERNMENT PRINTER, NORTH TERRACE.

1912.

TABLE OF CONTENTS.

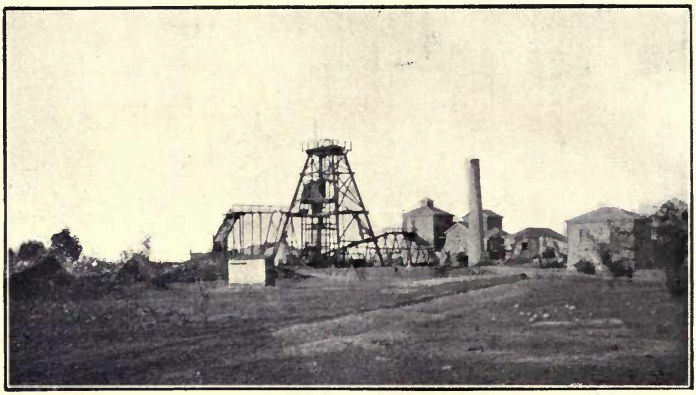
PHOTOGRAPHS.

MAPS AND PLANS.

TABLE OF CONTENTS.

PHOTOGRAPHS.

MAPS AND PLANS.



Paramatta Main Shaft and Mill.

Yelta Main Shaft and Smelters.

REPORT

ON THE

YELTA AND PARAMATTA MINES.

I.—INTRODUCTION.

A brief examination of the Yelta and Paramatta mineral sections was made by the officers of the Geological Survey of South Australia during the period extending from January 18th to January 25th, 1912. The following report embodies the observations made and the conclusions arrived at.

The examination of the leases was to no small extent hampered by the inaccessibility of many of the old workings, which are either full of water or fallen in. Under such circumstances inquiries were made from reliable residents as to the past history of the idle workings, and the generous response from all to whom application was made proved of great assistance. The information thus obtained shows that a considerable amount of copper ore was won from several of the flooded and disused workings.

The mineral sections, which comprise a total area of 1,349 acres, lie to the east and north-east of the township of Moonta, within a radius of two and half miles, and are crossed by the Moonta-Wallaroo railway line and the main road from Moonta to Kadina.

II.—GENERAL GEOLOGY.

Within the limits of these sections there are but few rock-types represented. The igneous rocks present belong to two groups—the older felsites and felspathic porphyries and the younger pegmatitic dykes. The only consolidated sedimentary rock is a quartzitic conglomerate, which is found in a portion of the Wheal James section 1216. The types mentioned constitute the basal rocks of the area and are entirely covered by a mantle of travertine, clay, and sand.

The older series of igneous rocks comprises a number of types, the outward habit of which is variable. Both in the presence or absence of schistosity and in the proportion of phenocrysts to ground-mass the members of this group vary rapidly from point to point; yet the several varieties are so closely associated in the field that the essential unity of the group is undoubted. There has been some differentiation of the molten rock-magma, which has resulted in the genesis of porphyritic and non-porphyritic types; and the crushing which has succeeded consolidation has been selective, so that in some places igneous schists are found and in others the igneous rocks remain massive and free from signs of dynamic metamorphism.

The phenocrysts recognisable by the unassisted eye are quartz and pink felspar. These are distributed through a ground-mass which is pink or green in color.

Thin sections of the rock show that the felspar is almost, if not entirely, plagioclase, with low to medium extinction angles. Biotite is scattered through the ground-mass in short rods and scales, and in some instances it attains larger dimensions. It is in part altered to chlorite.

Some anhedral grains of apatite are visible in the irregular groups of larger crystals. Aggregates of granular quartz and biotite occur scattered through a microcrystalline ground-mass.

The pegmatite dykes referred to are better known on the mines as lodes, for the reason that they carry the metallic minerals as original constituents in sufficient quantities to render them of economic value. Both the metallic and the non-metallic constituents are on the whole coarsely aggregated; but actual crystal boundaries are seldom visible. From the description of the non-metallic constituents of these dykes in the later pages of this report it will be seen that they are such as indicate a derivation from a granitic magma; yet no granite has yet been found in the area examined. It is of interest to note that these pegmatites show no sign of the schistosity which is so prominent a feature of portions of the felspathic porphyries.

The pegmatitic dykes traverse the schistose igneous rocks, and apparently made their intrusion some considerable time after the consolidation of the latter.

Of the quartzitic conglomerate little can be said. The grain is variable, the particles ranging in size from a thirtieth of an inch up to 2in. in diameter. The color is yellow to red, and the rock is firmly cemented by an infiltration of silica. This rock has not been seen actually *in situ*, but fragments of it are visible on the dumps of three shafts disposed in a line bearing N. 60° E. This apparent belt of the rock extends from a point six chains west of the railway line for a distance of 14 chains to the west-south-west. Such sedimentary rocks are of peculiar interest from a geological point of view, in that they are likely to afford the clue to the structure of the district. The information available with regard to this particular occurrence is, unfortunately, inconclusive.

The superficial covering, which completely masks the rocks throughout the area, is of variable thickness and composition. In some places the basal rock is found decomposed, *in situ*, at a depth of only a few inches. In other places the prospecting pits show the presence of several feet of sand, travertine, and clay.

The travertine consists for the most part of calcium carbonate, with which are mingled clay, sand, and fragments of the decayed felspathic porphyry. The structure is in almost all cases concretionary. This deposit is formed by the evaporation of the water which circulates through the shallow belt of disintegrated rock lying immediately below the surface. The carbonate of lime is taken into solution by the water, and is precipitated when the solvent approaches sufficiently near to the surface to be evaporated. The rainfall of the region is small, and there are no defined watercourses to convey the rainfall to the sea. The rain that falls sinks to a large extent into the soil, and carries down with it as much mineral material as it is capable of holding in solution. During the dry seasons the underground water ascends into the zone of evaporation under the influence of capillarity and through the larger channels of the underground circulation. As a net result of these processes a sheet of this calcareous cement is formed, which migrates downwards with the degradation of the region.

This rock has been extensively quarried for building and road-making purposes. It is not well suited as flux for the ores of this particular area, for the reason that it contains a fairly high percentage of silica derived from the inclosed impurities.

With regard to the geological structure of the region, the examination of this restricted area gives no positive information. The older igneous rocks extend beyond the limits of the area under discussion. Save for the narrow belt of grit and conglomerate in the north-western portion of the leases, these igneous rocks are believed to be continuous.

There is no definite evidence to show whether the intrusive or the effusive phase of igneous activity is represented by these rocks. No fragmental types were observed either in the underground workings or in the dumps around old shafts, and no vesicular types were recognised.

The relation, therefore, of the conglomerate mentioned above to the igneous rocks remains undetermined.

At a period later than that of the consolidation of the older igneous rocks, but prior to the formation of the lodes, crustal stresses have produced various degrees of schistosity in the country rocks. The elaborate jointing of these rocks was probably induced at the same time by the same influences.

The next geological processes of which the district bears witness are the fracturing of the older rocks and the introduction of the lode-forming constituents.

Thereafter no traces of the operation of constructive geological processes remain within the area covered by this examination. Destructive agencies have, however, been almost continuously at work over immense periods of time, and have achieved the reduction of a very large area to a peneplain.

The peneplained surface is covered with a shallow mantle of clay, sand, and an impure travertine, which effectively mask both country rocks and lodes.

III. ECONOMIC GEOLOGY.

(*a*) Structural Features.

The total effect of the constructive and destructive forces briefly tabulated above is the production of a land surface which offers exceptionally favorable conditions for transport. On the other hand, the lodes do not appear at the surface, and they can only be located by systematic trenching or boring.

The early prospectors of the district proved that the general trend of the lodes is in a north-easterly and south-westerly direction, and this knowledge was used to advantage in the pegging and prospecting of the Yelta sections. It is undoubtedly true that in a general sense the lodes exhibit this tendency. The crustal stresses have found relief by actual fractures of the rocks along directions which are approximately parallel. Within the area examined at least 12 such fractures filled with lode material are known. It is impossible to trace a connection between certain of these fractures for want of sufficient exposures. Some of them may be collinear; but it is essential to remember that several fractures exist, and that the correlation of any two lode-filled fractures which approximately correspond in trend, but are some distance apart, is not justifiable. On this ground alone, quite apart from the fact that no examination of adjacent properties was made, it is impossible to identify the lode fissures of the Yelta mine with those of neighboring mines.

The lodes show a general tendency to follow a course which is, within the Yelta sections, nearly north-east and south-west, but which, in the Paramatta sections to the northward, is almost east-north-east and west-south-west. The dip of all the lodes with regard to which definite information is available is towards the north-west, at angles which do not differ much from 60°.

The fracturing of the country rock as revealed by the underground workings has been of a rather complex character. Lenticular blocks of country rock—"horses"—are at some places inclosed in lode matter. At other points the deposition of ore has taken place on one side only of a displaced block, the other fracture being marked merely by a seam of rock-meal or "flucan. In such cases it may be necessary to dislodge the country rock lying between the lode and the flucan seam, to keep the stopes open and safe. There is no definite proof of actual dislocation of the lodes by faulting in the workings

examined. At the north-eastern end of the main ore-shoot of the Yelta mine there is the semblance of a dislocation of the lode, which may possibly be caused by subsequent filling of a fracture of which the course has been influenced by joint planes.

The fissures are traceable beyond the limits of the ore bodies, which occupy only certain portions of them. The track of a fissure beyond the lenticular "makes" of lode material is indicated by rock meal, in which occasional splashes of lode matter are discernible. The ore bodies which were observed are lenticular chimneys, the outlines of which have been determined by the variable accessibility of different portions of the fissures to the invading material.

The ore bodies are not merely fillings of open portions of the fissures, for there are clear evidences of the enlargement of the channels by the chemical corrosion of the wall rocks. This process of replacement has resulted in local swellings in the ore bodies and in the merging of the lode matter into the wall rock.

The first condition necessary for the formation of a lenticular body is thus seen to be a portion of a fissure which affords a relatively easy passage to the uprising lode-forming material. The distribution of these more pervious portions of the fissures demands investigation throughout the whole district.

The internal structure of the lodes is variable. The banding of the constituents is in places noticeable, but is not present throughout. The cores of the lodes are more coarsely crystalline than are the outer portions.

(*b*) Primary Mineralogical Composition.

The minerals present in the primary lode matter (*i.e.*, the lode matter of which the original contents have not been altered by secondary processes) are numerous, and are present in very variable proportions in different parts of the lode.

The whole assemblage, or "vein-type," includes chalcopyrite, bornite, hæmatite, pyrite, molybdenite, traces of gold, silver, and bismuth, quartz, biotite, microcline felspar, tourmaline, and fluorite.

Chalcopyrite is much the more important copper-bearing mineral, and is invariably massive. Bornite occurs sparingly, save at a few points.

Hæmatite is abundant, and is an important constituent of almost all portions of the shoots in the Yelta main lode workings. It is at this place massive, in some cases replacing octahedral crystals of magnetite. In the eastern lode on the Yelta sections the hæmatite is in a pulverulent state, and is distributed through the crevices of the quartz, to which it has imparted a deep, red color. In the main lode of the Paramatta mine the amount of hæmatite present is almost negligible.

Pyrite is noticeably scarce in all parts of the mine open to inspection.

Molybdenite occurs in sporadically distributed bunches, in fairly massive "books," which show in some instances rude crystallographic outlines.

Gold and silver are not visible in the ore, but have been detected in the matte. In a sample of this matte, produced during the last campaign, gold is present to the amount of 1oz to the ton of copper, and silver is present in traces. Owing to the fact that some ore from external sources was purchased by the company during this period it is uncertain whether all of this gold and silver is derived from the lodes in this property. Bismuth is stated to have been present in minute quantities in some of the ore mined; but it was found to be absent from the matte, of which a sample was obtained.

Of the non-metallic gangue minerals, quartz is by far the most abundant.

The mica is of next importance in the matter of bulk. It is to be mineralogically classified with the biotites, as may be seen from the following analysis by Mr. W. S. Chapman, Departmental Analyst and Assayer :—

Silica	40·66
Titanic dioxide	0·60
Alumina	24·28
Ferric oxide	0·86
Ferrous oxide	14·01
Lime	0·60
Magnesia	7·02
Soda	0·62
Potash	9·24
Water at 100° C.	0·22
Water above 100° C.	0·78
Phosphoric anhydride	0·21
Fluorine	present
	99·10
Specific gravity	3·06

The color of the mica is a deep greenish brown. It occurs in massive " books " and aggregates of " books," with the metallic ingredients of the lodes mechanically enclosed between the leaves and aggregates.

The felspathic portion of the gangue is irregularly distributed. The felspar represented is a typical pink microcline, of which the following analysis has been made by Mr. W. S. Chapman :—

Silica	64·41
Alumina	18·31
Ferric oxide	0·77
Lime	0·62
Magnesia	0·22
Soda	1·54
Potash	14·04
Water at 100° C.	nil
Water above 100° C.	0·28
	100·19
Specific gravity	2·58

The tourmaline is the black variety, commonly known as schorl. It is either massive or in the form of rods penetrating the other lode constituents, and in one instance was seen mutually inter-grown with orthoclase. The schorl is present both in the ore-shoots and in the non-cupriferous portions of the lode.

Fluorite is not abundant. It possesses a deep amethystine color.

Pyroxene is present in small amount, apparently at the places where some considerable degree of replacement of the wall rock has occurred. It is not seen in the actual body of the introduced lode-matter, and is therefore regarded as a probable product of the alteration of the country rock.

(*c*) The Paragenesis of the Minerals.

The paragenetic association of the minerals tabulated above is of singular interest and significance.

The grouping of the gangue minerals is essentially that of a pegmatite dyke, and the co-association of the metallic minerals should in no way invali-

date this classification. In other words, the direct igneous origin of the veins of this type is self-evident. Veins of precisely this type do not appear to have been previously recorded in detail in geological literature, although their existence has been indicated by W. H. Weed* and by H. H. Thomas and D. A. MacAlister.†

The veins are, on the one hand, genetically related to actual igneous intrusions, and on the other hand to the most deeply-seated types of veins.‡ From these considerations it is plain that the copper contents of the lodes have been derived from a still more deeply-seated source, and that they have been deposited in their present position by the influences of diminishing temperature and pressure. Though originally deposited at a considerable depth below the surface, they have been rendered accessible by the gradual lowering of the surface.

How much of the actual lodes themselves has been lost by the long-continued operation of the agents of denudation it is now impossible to determine. The vertical range of the cupriferous portions of the lodes at the time of ore-deposition is unknown. There is reason to believe that the present surface has truncated the lodes, and it appears that the lower limits of the cupriferous zone have not been reached by the lowest workings in the Yelta or Paramatta mines.

(*d*) The Secondary Alteration of the Lodes.

The mineralogical description given above is applicable to the vein-matter at the time of its formation. Those portions of the veins which have been brought into proximity to the surface by denudation have suffered either loss or alteration of some of their components.

The chalcopyrite has in some instances been partially converted into tenorite (black oxide of copper), or more rarely into covellite. At the surface malachite and atacamite are reported to have been found by the early prospectors at the Paramatta Mine; but neither mineral was visible in appreciable proportions in any of the lodes examined by the writers.

The molybdenite of the primary ores is covered with a film of molybdic ochre in the oxidised zone. Kaolin results from the decay of the orthoclase and is visible in the non-disintegrated superficial vein-stuff. Limonite is in many places found immediately below the surface, and in conjunction with angular fragments of quartz indicates the proximity of a lode channel.

The quartz and tourmaline of the lodes are the most resistant constituents, and survive almost at the very surface in portions of the veins which show extensive chemical decay.

The secondary alteration of the shoots has not resulted in the accumulation of any appreciable deposits of oxidised ore within the area covered by this report, save at one place near the Paramatta main shaft.

The general absence of the green ores—malachite and atacamite—from these sections had undoubtedly a deterrent effect upon prospecting. Throughout the sections lodes have been located by shallow trenches cut in search of green ore; but in very many instances no attempts have been made to test the lodes thus exposed to any depth.

A much more detailed investigation of a wider area is necessary before a definite conclusion can be reached with regard to the factors controlling the distribution of green ore. It is possible that there may be a causal connection between the amount of clay present at the surface and the bunches of green

* "Copper Mines of the World," Type 1., p. 73.

† "The Geology of Ore Deposits," p.p. 56 and 71.

‡ W. H. Weed, loc. cit. supra, Types 8 and 9, p. 76; also W. Lindgren, "Economic Geology," vol. II. ii, p. 111.

ore. Assuming for the moment that such a relationship does exist, the process known as "adsorption"* suggests itself as the controlling principle. Judgment on this matter must be reserved, pending an examination of the whole district.

IV. THE EARLY HISTORY OF THE MINES.

There is no means of compiling a complete account of these mines from official records, and the following notes constitute only a brief outline of the salient events in their past history. Being derived from unofficial sources, these notes lack specific information on many important points, such as the depths of old and inaccessible workings, the tonnage and grade of the ore raised from such workings, and the amount of development beyond the limits of pay-shoots.

The earliest attempts to develop the property date from 1864, when a company was formed to work the Yelta mine. The first work was done near the south-western boundary of the sections adjoining the Moonta Mines' property, on which latter discoveries of copper ore had already been made.

The shafts sunk and the trenches cut on the south-western boundary of section No. 1002 only proved the siliceous cappings of lodes. It was at a much later period that the eastern shaft workings penetrated to a depth of which sulphides occur. These more recent mining operations have been restricted to only one of the lodes located by the very early prospecting. These other untried lodes have not been touched since the cappings were uncovered, largely for the reason that the absence of green ore, for which search was being made, was regarded as an unfavorable sign. That this theory is not of general application has been demonstrated by the discoveries of ore shoots beneath barren cappings at the eastern lode workings, and at the Yelta main shaft.

A greater measure of success attended the first work done near the boundary line between sections 1061 and 1152. A trial shaft was sunk within a few chains of the Moonta boundary to a depth of 156ft., and yielded a small quantity of rich ore from a well-defined lode. A little later Scott's shaft was started on Wearing's lode, and during the succeeding 10 or 12 years some hundreds of tons were hauled from it. During this period it was carried down to a depth of 338ft. on the lode. Wearing's shaft, close to Scott's and on the same lode, was used for ventilation and haulage. A third shaft, known as Hughes's shaft, about 600ft. to the north-east of Scott's, was sunk to a depth of 180ft., and yielded good ore in fair quantity.

Hancock's lode lies a little to the south-east of Wearing's lode, and has been proved by several shafts, of which that known as Hancock's attains a depth of 240ft., while Lindsay's shaft, a short distance to the north-east, was stopped owing to the inflow of water. Although the amount of this inflow may have been comparatively small, in considering the question of reopening these workings the problem of dealing not only with the water accumulated in them, but also with a probable large quantity from other sources, would have to be faced.

Fairly extensive workings exist in section 1497 to the east-south-east of the present main shaft. These old workings have collapsed, and have long been flooded. There is good reason to believe that considerable quantities of ore were raised from them, though no figures can be quoted.

---

* "Adsorption" is the property possessed by some substances, such as clay, of retaining a part of the substances dissolved by highly dilute solutions which pass through them. *Vide* R. Beck, "The Nature of Ore Deposits," Weed's Translation, vol. II., p. 526.

A shaft, known as the Tank shaft, and probably identical with the New Discovery shaft, shown on the plan of the sections accompanying this report, is stated to have been sunk to a depth of 240ft. Tuxford's shaft is stated to have reached the same depth, the first 60ft. being vertical, and the deeper portion following the dip of the lode. Wigley's shaft (? Wyley's) was sunk to a depth of 90ft., where it was stopped by water.

The vertical shaft started by the Comte de Venancourt, general manager of the last company operating the mine, is in good order. If sinking is continued to a depth below the old workings, the two lodes which exist at this place can be opened up. The shaft is equipped with a small head gear, winch, and air receiver, power having evidently been furnished from the compressors at the main shaft.

Shortly after the opening of Wearing's and Hancock's lodes the workings at the present main shaft were commenced, and during the few succeeding years were carried down to the 540ft. (90 fathom) level. It will be seen from the longitudinal section of the lode that above the 210ft. (35 fathom) level a comparatively small portion of the lode carried stoping ore. Between the 210ft. level and the 390ft. (65 fathom) level almost the whole of the ore in the main shoot was stoped out. Below the latter level the same shoot was only partially depleted.

Difficulties in the wet concentration of this ore, on account of the large amount of hæmatite present, caused the cessation of work pending the raising of further capital. A local syndicate then obtained the right to work the mine, and after an unsuccessful attempt to unwater the main lode workings turned their attention to Wearing's and Hanocck's lodes previously referred to. Their efforts were on the whole unprofitable.

The company resumed operations at the main shaft in 1895, and, having unwatered the mine, sunk the shaft to a depth of 720ft. (120 fathoms) and drove two levels. The only ore raised during this period came from development work, the problem of the treatment of the ore having remained unsolved.

The Paramatta Mine, including the Wheal Hughes and Wheal James Mines, had been intermittently at work during this earlier period. The only information available with regard to the history of these mines is to be found in "The Record of the Mines of South Australia, 1908."

In 1903 the Yelta Mine was acquired by the company which owned the Paramatta Mine, and which had resumed active operations there about 1900. This company inaugurated blast furnace treatment in 1904, and continued smelting until it ceased operations in November, 1907. During this latter period the copper won from the Yelta and Paramatta Mines is valued at about £250,000.

Between the end of 1907 and its purchase by the South Australian Government in December, 1910 the mine lay idle.

V. DESCRIPTION OF THE MINES.

(*a*) Yelta Mine.

The most extensive workings on the Yelta sections are situated near the southern corner of the Moonta Central lease, and are operated from a main shaft extending on the underlie to a depth of a little over 1,200ft. (200 fathoms).

In contrast to the extent of these workings in depth, it may be pointed out that the maximum length of the lode fissure explored by the former lessees is only 402ft. to the north-east of the shaft and 396ft. to the south-west. Within this limited portion of the lode channel two shoots of ore have been located. The north-easterly shoot has been proved to extend from the 210ft. (35 fathom) level to the bottom of the mine. It has been

stoped for an average length of 414ft. and a width of about 6ft. between the 210ft. and the 1,080ft. (180 fathom) level. Below the 720ft. (120 fathom) level the mine was full of water at the time when this examination was made; but the plans indicate that the shoot extends to the full depth of the workings.

Above the 960ft. (160 fathom) level comparatively little ore remains in this shoot; but below that depth very little stoping has been done.

The south-western shoot at the present time contains the largest known block of ore in the mine. This shoot has been blocked out between the 390ft. (65 fathom) and the 960ft. (160 fathom) levels, and has been almost depleted between the 390ft. and 462ft. (77 fathom) levels. With the exception of small leading stopes at three levels the remainder of the shoot is intact. The upward extension above the 390ft. level is now being proved by a rise in the lode and a south-westerly drive on the 270ft. (45 fathom) level, both of which are in ore. The width of the shoot is from 4ft. to 8ft., and the stope length where fully exposed averages 120ft.

No attempt whatever has been made to prove the vertical extension of this shoot beyond the limits indicated.

At the present time a prospecting drive is being carried along the lode-channel at the 390ft. level beyond the lateral limits of the last-mentioned shoot in a south-westerly direction in search of other possible shoots. In view of the fact that the main shoot did not persist to the surface, and that there have been found indications of copper in a parallel lode at the prospecting shaft still further to the south-west, this deeper prospecting of the main lode channel is certainly advisable, and will have an important bearing on the future of the mine.

All these portions of the main lode workings have been operated from the main shaft, which was sunk vertically to a depth of 90ft. before turning to follow the dip of the lode. The inequalities in grade, caused by the slight irregularities in the dip of the lode, and, of still more serious import, slight variations in direction, render the shaft unfit for rapid hauling. The shaft is divided into three compartments, of which the north-easterly one is occupied by the pumps and an emergency ladder-way, the others being used for hauling with skips capable of hoisting 15cwts. of ore. A certain amount of trouble is being experienced during the process of unwatering, as the accumulated copper-bearing water has destroyed the ironwork, and so caused the timbering to collapse in several places. The lower workings are being steadily drained by a large air-driven pump following the water down and delivering to the lowest available sump of the Cornish pump, and by two baling-skips discharging on the surface.

Periodical tests have shown that so far the copper content of the water is too low to admit of the copper being recovered; but some copper has been obtained by scraping the precipitate off the rails and other ironwork in the shaft and levels. Spongy masses, 3in. in diameter, formed along the old rails in the levels that were submerged, with partial or complete destruction of the iron.

Some of the levels have been lost in places or, at the least, damaged by the water having caused the filling to run through the lagging. In some cases in the main shoot the filling of depleted stopes has subsided as much as 30ft., and it has been necessary to refill them to carry the roadways giving access to the south-western shoot of ore, where preparations for the resumption of stoping are being made as fast as the lowering of the water permits.

The country, as a whole, is very good standing ground, practically no timber being required, save to maintain the levels and shoots through the worked-out ground, and occasionally along the barren portion of the lode channel. There is, however, a fissure or seam on the hanging-wall side of the lode, roughly parallel to the lode, which sometimes gives a little trouble and pre-

vents the use of any system of stoping, involving the leaving of very extensive openings. The " semi-shrinkage " system of stoping was used by the previous company, and appears to have been satisfactory. The ore broken in the stopes is run into chutes, and trucked to shaft bins feeding the skips, in which it is hauled to the surface.

The surface equipment of the Yelta Mine is fairly complete, and is being put into working order, as required, after its period of disuse. There is a suitable headgear and a good double-drum geared winding engine by Walker Bros. at the main shaft.

The ore on reaching the surface is tipped over grizzlies, which deliver an oversize product on to the ground. The undersize is elevated to the sorting plant. After screening out the finest material, the residue is sorted on a travelling belt, waste and a certain amount of molybdenite being picked out. Some experiments are being made by the manager on the " fines," and indicate that coarse jigging successfully removes the excess of silica and raises the copper-hæmatite contents to make a very desriable furnace feed.

The waste rock picked from the ore is sent underground to be used for filling, and the ore is stacked in the yard pending the resumption of smelting operations. It is proposed to install bins here to do away with the shovelling of ore from the ground into the smelter barrows.

There are two smelters, both in good order. The newer, called No. 1, is rated at 65 tons daily capacity, and is made up of two tiers of water jackets. It was only in use a few months, as the bulk of the smelting was done in the old or No. 2 furnace. This furnace is of the same size, but, having only one tier of jackets and a brick column, was less economical. Both have the usual jacket-water pumps and accessories. Blast was supplied to the smelters by one Roots and three Baker blowers, which are now being overhauled. In the same building is a small repair shop equipped with a lathe, shaper, and screw-cutting machine. The blowers and repair plant are belt-driven by a horizontal simple engine.

Power for rock drills and underground pumps is provided by two small compressors coupled to an air receiver. The larger, an 8-drill compressor, by Martin, was being used at the time of inspection, and was supplying the sinking-pump in the shaft and one or two drills. The other is a straight-line Ingersoll-Rand, of six drills capacity.

One Lancashire and three large Cornish boilers furnish steam to the various engines.

It may be said that the power plant, as a whole, is capable of satisfying the immediate needs of the mine.

In addition to the buildings housing the plant there are various sheds and stores, a slag-brick smith's shop, and stone assay, and general offices suited to the needs of a large mine.

There are a number of workings other than those on the main lode described above which possess no little interest.

To the north-west of the main line of lode another lode has been cut in an exploratory crosscut at the 210ft. level. This lode is 9ft. in width, and though poor at the place where it was intersected is worthy of further attention, since it is mineralogically identical with the poorer portions of the main lode.

At a point some 900ft. south-west of the main shaft a vertical prospecting shaft has been sunk to a depth of 190ft. with the object of prospecting both the western lode and the southern extension of the main ore channel. This shaft followed a quartzose lode to a depth of 110ft. before the dip of the lode becomes normal, and carries the vein-stuff out of the shaft to the north-west. This lode may provisionally be assumed to be that which has been mentioned as located in the north-westerly crosscut referred to above. The last portion of this lode seen in this shaft carries a little copper.

At the bottom of the shaft a belt of country rock carrying a little disseminated copper pyrites was being passed through at the time of this examination. The mineralisation at this point may be related to a lode located in a trench 115ft. south-east of the prospecting shaft.

When a depth of 200ft. has been reached it is intended to crosscut to the north-west to intersect the lode on which the shaft was started, and to the south-east for the main lode, which is visible on the surface 330ft. from the shaft, but which dips towards it.

The Prospecting shaft has a small headgear and a vertical boiler and winch suitably housed.

At a point half a mile south by east from the main shaft are situated the Eastern shaft workings, which were opened up by the last company and extended by the present management. Here a shoot of ore was stoped to a width of 4ft. over a stope length of 43ft. by the company, and by tributors from the 153ft. level to within 30ft. of the surface. Records have been preserved showing that 343 tons of ore, assaying 28·73 per cent. of copper, were won ; and it is believed that, in addition to this amount, some lower-grade material was smelted at the Yelta furnaces. Prospecting for the downward extension of this shoot of ore was recently undertaken; but owing to the necessity for conserving the available funds for more urgent work, insufficient has been done to afford definite information with regard to the ore body in depth. Since an appreciable amount of high-grade ore has been won and the extension of the lode to the south-west has been proved by trenches for many chains, the work of prospecting should be resumed at the earliest opportunity.

These workings can be cheaply and quickly unwatered when it is deemed expedient, as the shaft is in good order, and the enginehouse contains a winch and vertical boiler.

At the present time the task of reopening the main workings and of making the necessary preparations for the resumption of productive operations is the principal objective of the management. As the shaft is being unwatered the repairs consequent upon so long a period of idleness cause a little inevitable delay ; but these difficulties are being successfully surmounted, and already the mine is in working order to a depth of 720ft.

(*b*) Paramatta Mine.

The Paramatta Mine at the present time lies idle. There is one main line of lode which has been traced on a course bearing on the average 60° east of north for a distance of almost a mile. The principal workings are situated round the No. 3 or main shaft, which has been sunk to a depth of 810ft. on the underlie.

The mine is full of water, and could not therefore be examined. An inspection of the plans, however, shows that the workings are fairly extensive in depth, and that the ore, as in the Yelta Mine, occurs in two main shoots. Down to the 522ft. level the lode appears to have been practically stoped out as far as the main or north-eastern shoot is concerned. Between that level and the 720ft. level this shoot has been practically depleted for a length of 180ft. in the immediate vicinity of the main shaft.

The south-western shoot has been stoped for a length of 270ft. on the 492ft. level, and has been proved to extend with a south-westerly pitch to the 612ft. level, which is already connected with the 492ft. level by a rise believed to be in ore; but no stoping has been done below the 492ft. level. The plans certainly show that below the 612ft. level an altogether insufficient amount of prospecting has been done.

On the same line of lode, and 30 chains to the south-west of the main shaft, is Cooper's shaft, which was sunk to a depth of 156ft. on a part of the lode in which copper pyrites is associated with much iron pyrites. From the size of the dump round this old shaft it may be judged that the workings are of some importance.

The ore derived from this lode is different in character from that of the Yelta main lode, inasmuch as molybdenite and hæmatite are seldom seen. The absence of the latter renders the ore capable of concentration.

A large bin excavated below ground level received the ore hoisted from the mine and, on occasion, concentrating ore brought from Yelta over a 3ft. 6in. gauge line belonging to the mine. From this bin the ore was drawn up an incline and dumped beside a jawbreaker. Thence it passed through Cornish rolls, and when sufficiently fine lifted by a wheel elevator to a Hancock jig. The overflow, with its suspended slimes, passed to a settler. The thickened product was treated on Wilfley tables. This plant is considerably worn, and a good deal of woodwork requires renewal before it is again fit for use. It and the Cornish mine pump were driven by a simple non-condensing 24in. x 48in. horizontal engine. A three-drill compressor and air-receiver served the rock drills; and a double cylinder geared double drum winding engine by Martin stands ready for use. Steam was supplied to the whole plant by two Cornish boilers, which are said to be in good condition. The buildings include a magazine, stables, and manager's cottage.

At least one other lode besides the main lode has been proved to exist by a long surface trench to the north-west of the principal workings. The amount of prospecting that has been carried out by no means exhausts the possibilities of the area.

VI. CONCLUSION.

As a result of the geological examination which has just been made, several points of economic significance demand notice and discussion. Some of these noteworthy points have to do with the actual facts of occurrence with which the immediate problems of mining and metallurgical work are concerned. Others deal with the geological deductions and concern chiefly the future prospects of the property.

In the first place there are a few matters of comment with regard to the mineralogical character of the ore. The ore for treatment is wholly primary, and is of a distinctive type. From the point of view of the metallurgist the ore is neither typically acidic nor basic in character. On the one hand there are present a certain amount of free silica and siliceous minerals in the gangue. On the other hand the iron contents of the lode are high, and the greater part of the iron occurs in the form of oxide rather than sulphide. The result is that the sulphur content of the ore is low when the amount of iron present is considered.

Analyses that were made of ore smelted in January, 1904, show 35 per cent. of silica to 44 per cent. of ferrous oxide and 7 per cent. of sulphur. This ore contained 4·72 per cent. of copper.

Chalcopyrite shows a greater tendency to make slime than either hæmatite or pyrite, both of which have a greater specific gravity; therefore the attempts made to raise the tenor of the ore by simple mechanical concentration were attended by heavy losses of copper, and were abandoned as uneconomical in favor of direct smelting of the mine product.

Results of the actual smelting of this ore show that a high-grade copper, free from deleterious ingredients, has been produced.

It has been indicated above that gold has been found to be present in a specimen of matte from the last campaign. Lodes in which tourmaline is associated with quartz and chalcopyrite are recognised as belonging to the gold-bearing types. This point should ever be kept in mind, both in the work of prospecting and in considering the value of lode material as possibly payable ore.

The amount of molybdenite present in the ore is small, but it occurs in pieces which are large enough to be readily saved as the ore passes over the sorting belt. The amount recovered is stated to have been 2 tons or 3 tons per annum. The present market value of molybdenite is £186 per ton.

Apart from these mineralogical features of the lodes, there are other matters concerning structure and the geological relationships of the ore bodies which are of no small economic importance.

The structural features of the lodes have already been mentioned in some detail; but there is one matter of vital importance to the future of the mines which demands further discussion. It has been pointed out that the known ore-shoots occur along planes of dislocation marked by rock-meal or flucan. As far as a plane of dislocation which is known to be ore-bearing may be traced, it is possible that other shoots of ore may be found along it; for while the earth-fracture can be followed laterally, there is the possibility of discovering a channel penetrating to the source of origin of the ore. The south-westerly drive on the 390ft. (65 fathom) level in the Yelta main workings is thus a very valuable piece of prospecting work.

The conclusions arrived at with regard to the geology of the ore bodies of the Yelta and Paramatta Mines are here stated only for the properties in question. Their wider application is for the present unadvisable, for the reason that they are not based upon observations beyond the limits indicated. The essential unity of the cupriferous lodes with pegmatitic dykes derived from a granitic magma should be here insisted upon. It is, therefore, of the very greatest importance for the intelligent prospecting of the State that the distribution of this granite in time and in space should be ascertained.

If the period of this granitic invasion can be fixed, and if the granite genetically associated with the copper lodes can be accurately distinguished from other igneous rocks of granitic type, much of the labor and expense of prospecting will be eliminated.

Before any pronouncement on these points sufficiently authoritative to be of practical value is justifiable an intimate knowledge of the copper fields of a large portion of the State must be acquired. This knowledge can only result from detailed investigations in the field, accompanied by exact geological mapping, as has been done in the case of some of the goldfields of South Australia.

As regards, however, the actual mines with which this report deals there are certain special recommendations with regard to prospecting that can now be made.

If arrangements can be made to install a diamond drill underground in the Yelta mine it would certainly be advisable to pierce the lode located in the north-western crosscut at the 210ft. level at a greater depth in one or two places. If a payable shoot of ore is located in this lode by such boring a practically new mine will be opened up.

It is most essential that the diamond drill be used to test the downward continuation of the lodes formerly worked from the New Discovery and Tuxford's shafts. These lodes are believed to dip to the north-west at angles of approximately 60° and, as already stated, have been worked to a depth of 240ft. As, however, variations in the dip of the lodes may occur, as in

the case of the lode upon which the Prospecting shaft was sunk, it would be a wise precaution to incline the bore-hole at an angle of 60° from the horizontal and to drill it in a south-easterly direction. In order that such a bore may intersect the lode at a depth of 500ft. from the surface (measured along the underlie), it is necessary to start at a point 500ft. distant from the cap of the lode. Two such bores are to be recommended—the first from a point opposite Tuxford's shaft, and the second from opposite the New Discovery shaft. These positions and distances are selected to avoid, not only the risk of failing to cut the untouched portions of the lode through vertical deflection of the bores, but also the risk of missing the ore shoots through lateral deflection.

Some other points at which prospecting should be carried out have been indicated in the earlier pages of this report; but such work if carried out would by no means exhaust the possibilities of the sections. The backs of lodes have been uncovered in many places in the fruitless search for green ore; but despite the fact, already demonstrated in these mines, that the absence of copper at the surface does not necessarily mean a barren lode below, these lodes were left untested. This work, however, is less urgent than that which is here more definitely recommended.

To sum up—The immediate prospects of the property depend upon the results of the treatment of the ore from the main shoot below the 960ft. level and from the south-western shoot, and to some extent also from small blocks of ore left in the upper workings. Nothing is known of the grade of the main shoot in depth, except that stoping was begun upon it shortly before the mine closed down. The ore now lying at the surface and blocked out underground in the south-western shoot above the 720ft. level is of payable grade, and there is a sufficient amount in sight for a smelting campaign of several months.

As regards its future prospects the property may be said to possess considerable possibilities. Its potentialities include the deeper portions of the known shoots at the main workings of both the Yelta and Paramatta Mines, the lateral and vertical extensions of the eastern lode, and of the lodes immediately to the east of the new vertical shaft. The prospecting work now in progress at the prospecting shaft and the 390ft. level, south-western drive, will have a very important bearing upon the future of the mine. The prospecting shaft has already proved the presence of cupriferous lode-matter at a point hitherto untried and beneath a barren lode capping.

Should this or any other of the prospecting operations result in the discovery of a reasonable body of ore the future of the mine is assured, and the prospect of making these discoveries is sufficiently good to be taken into account when the value of the property is being estimated.

L. KEITH WARD, Government Geologist.

R. LOCKHART JACK, Assistant Government Geologist.

Adelaide, March 22nd, 1912.

SKETCH MAP
OF
YELTA AND PARAMATTA MINES
SHOWING POSITION OF LODES.

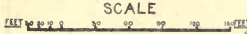
A. VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

YELTA MINE

SURFACE PLAN

FROM COMPANY'S PLAN.

SCALE

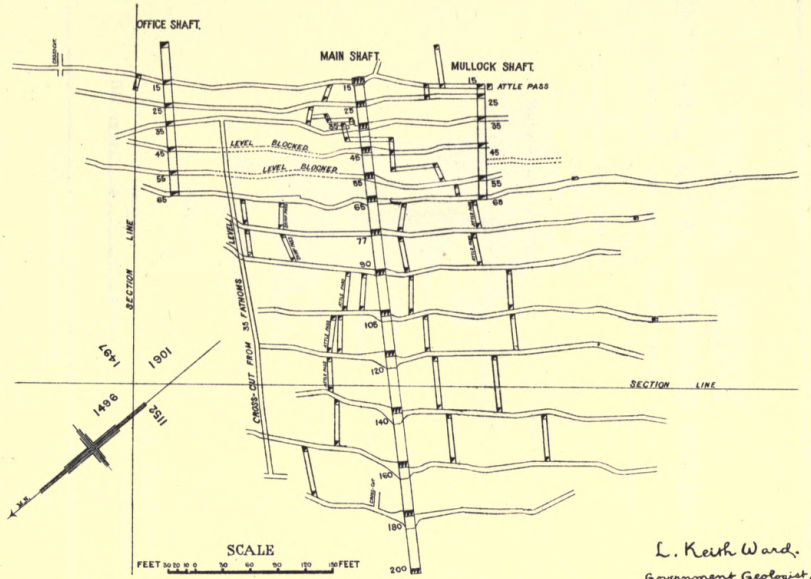


L. Keith Ward.
Government Geologist.

A. VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

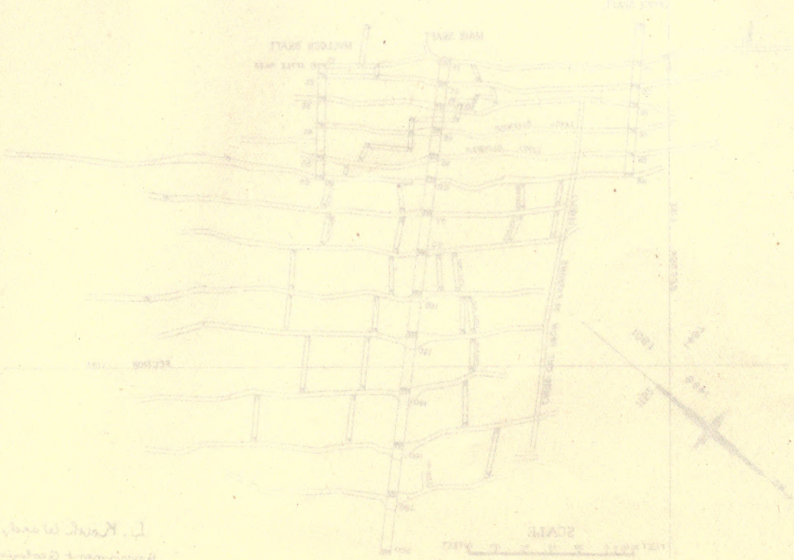
YELTA MINE

PLAN OF UNDERGROUND WORKINGS.



L. Keith Ward.
Government Geologist.

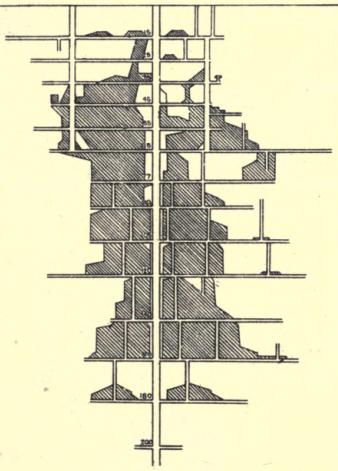
A. VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.



YELTA MINE

LONGITUDINAL SECTION OF UNDERGROUND WORKINGS.

OFFICE SHAFT. MAIN SHAFT. MULLOCK SHAFT.



SCALE

FEET 0 25 50 75 100 200 300 400 FEET

L. Keith Ward.
Government Geologist.

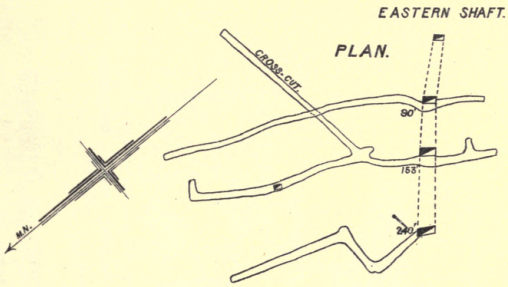
A. VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

YELTA MINE

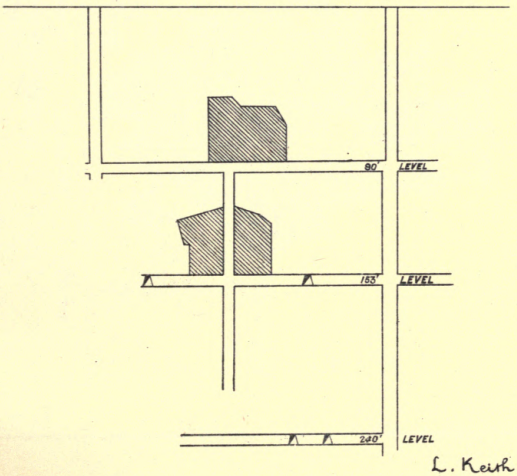
EASTERN SHAFT WORKINGS.

SCALE

FEET 20 15 10 5 0 20 40 60 80 100 FEET

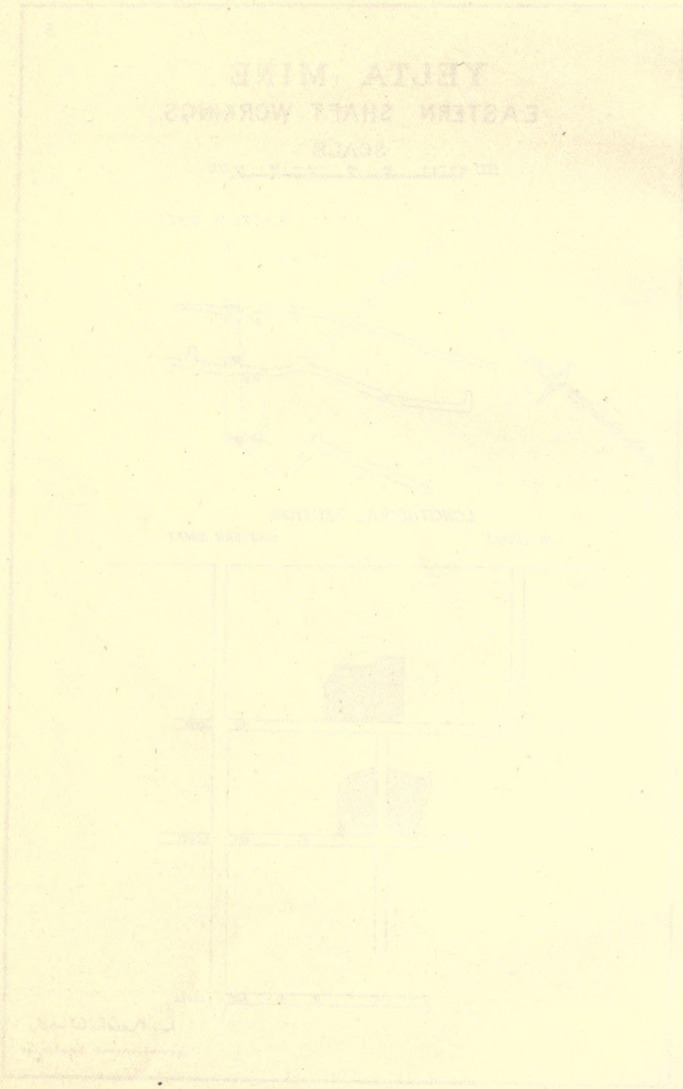


LONGITUDINAL SECTION.



L. Keith Ward.
Government Geologist.

A. VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

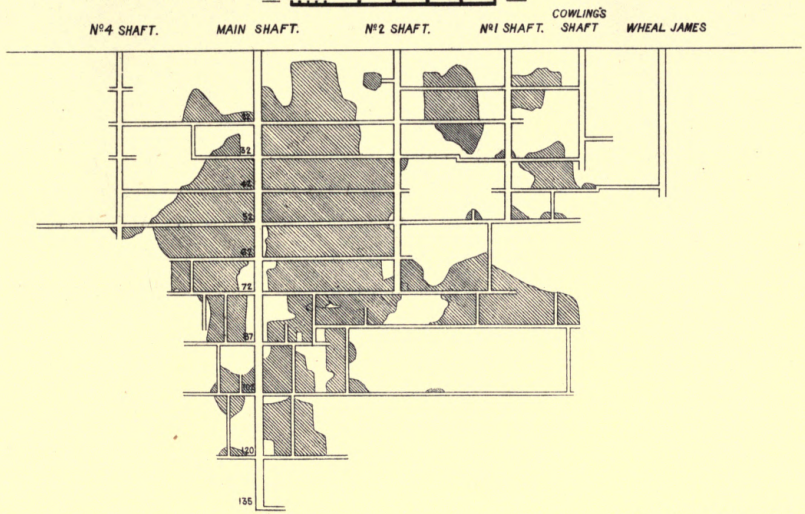


PARAMATTA MINE

LONGITUDINAL SECTION OF UNDERGROUND WORKINGS.

SCALE

FEET 60 40 20 15 0 60 120 180 240 300 FEET



L Keith Ward.
Government Geologist.

A. VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE.

PARAMATTA MINE

LONGITUDINAL SECTION of UNDERGROUND WORKINGS.

SCALE